CHAPTER – 12

BIOLOGICAL CLOCK

Biological clock is an **internal timing device** present in all living organisms. It is an invisible clock existing in every organism, including unicellular protozoans, plants and animals.

The rhythmic activities occurring in organisms are called **biological rhythms**. The biological clock is a **biochemical clock**, since it is based on biochemical reactions occurring inside the cells.

The biological rhythms may be characterised by several specific properties as follows;

1. **Temperature** changes alter the rate of most chemical reactions and cellular processes. Therefore, biological rhythms are **temperature-compensated**. It means that, generally, the rate of a chemical reaction doubles for each 10^0C increase in temperature.
2. Biological clocks are generally **unaffected by metabolic poisons** or **inhibitors** that block biochemical pathways within cells.
3. The period of **biological rhythm occur with approximately the same frequency** of one or more environmental features.
4. Biological rhythms are self-sustaining; maintain approximately their normal cycle even in the absence of environmental cues.
5. The biological rhythms can e adjusted according to input from the external environment.

CIRCADIAN RHYTHM:

Many organisms exhibit biological rhythms, governed by self-sustaining internal pacemakers of about twenty four hours duration, called **circadian rhythm**.

- Within the daily cycle, some animals' exhibit peak activity during the daylight hours called **diurnal**.

  Example: diurnal animals include humans, gorillas, chimpanzees, lizards, butterfly, honeybees, etc.
- Some animals are active primarily at night, called **nocturnal**.

  Example: nocturnal animals include foxes, owls, bats, etc.

- Still other animals exhibit peak activity around dusk and/or dawn, called **crepuscular**.

  Example: crepuscular animals include fire flies, young dragon flies, domestic cat, rabbit, deer, desert animals, etc.

CIRCANNUAL RHYTHM:

The behavioural and physiological patterns governed by self-sustaining internal pacemakers that occur with a period of about one year, called **circannual rhythm**.

- During winter season some mammals enter a condition of deep sleep and reduce metabolic activities called **hibernation**.

  Example: reptiles and amphibians, bees, etc.
- During summer season some animals become inactive and show lower metabolic rate, called **aestivation**.

  Example: desert tortoises, crocodiles and salamanders.
- The annual life cycle of many insects show a period of dormancy called **diapauses phase**.

  Example: the silkworm moths and mosquitoes lay eggs that are dormant during winter.

CIRCALUNAR RHYTHM:

A number of animals are known to exhibit rhythms of behaviour which corresponds to lunar (moon) cycle called **circalunar rhythm**.

Example: the menstrual cycle of women having a periodicity of 28 days.

ROLE OF PINEAL AND HYPOTHALAMUS IN RHYTHMS:

The pineal body is a **small organ**, the shape of the organ is **pine cone like**, hence the name p**ineal gland**. It is located in the geometric center of the brain, just behind the eyes.

The pineal gland secretes hormone called **melatonin**. This hormone communicates about environmental lighting to various parts of the body. Ultimately, melatonin has the ability to entrain biological rhythms and has important effects on reproductive function of many animals.

Synthesis and secretion of melatonin is affected by light exposure to the eyes. It is observed that the melatonin secretion is low during daylight hours, and increase to the peak during dark.

There is a pathway from the retina to the hypothalamus called **retinohypothalamic tract.** It brings information about light and dark cycle to a region of the hypothalamus called **suprachiasmatic**

nucleus (SCN). From the SCN, nerve impulses travel via pineal nerve to the pineal gland. These impulses inhibit the production of melatonin.

Ehen these impulses stop (at night, when light no longer stimulate the hypothalamus). Pineal inhibition ceases and melatonin is released.

The pineal gland is therefore a **photosensitive organ** and an important timekeeper for the human body.

Melatonin has important role in integrating photoperiod and affecting circadian rhythms. Consequently, it has been reported to have significant effects on reproduction, sleep-wake cycles and other phenomena showing circadian rhythm.

Day light
⇩
SCN of Hypothalamus
⇩
Pineal nerve
⇩
Pineal gland
⇩
Inhibited Melatonin production

Dark
⇩
SCN of Hypothalamus
⇩
Pineal nerve
⇩
Pineal gland
⇩
Enhanced Melatonin production

RETINOHYPOTHALAMIC TRACT

Effects on reproductive functions:

a. Melatonin is **anti-gonadotropic**. That is, melatonin inhibits the secretion of gonadotropic hormones, luteinizing hormone (LH) and follicle stimulating hormone (FSH) from the anterior pituitary. Therefore, it prevents onset of puberty before the appropriate age.
b. Seasonal breeders are regulated by the length of day. Long days inhibit melatonin and stimulate gonadal activity. Shorter days stimulate melatonin secretion.
c. **For example**, sheep that normally breed only once per year can be induced to have two breeding seasons by treatment with melatonin.

Effects on sleep and activity:

In various species of mammals including humans, administration of melatonin has been showed to decrease motor activity, induce fatigue and lower body temperature.

The effect of melatonin on body temperature may play a significant role to entrain sleep-wake cycles.

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